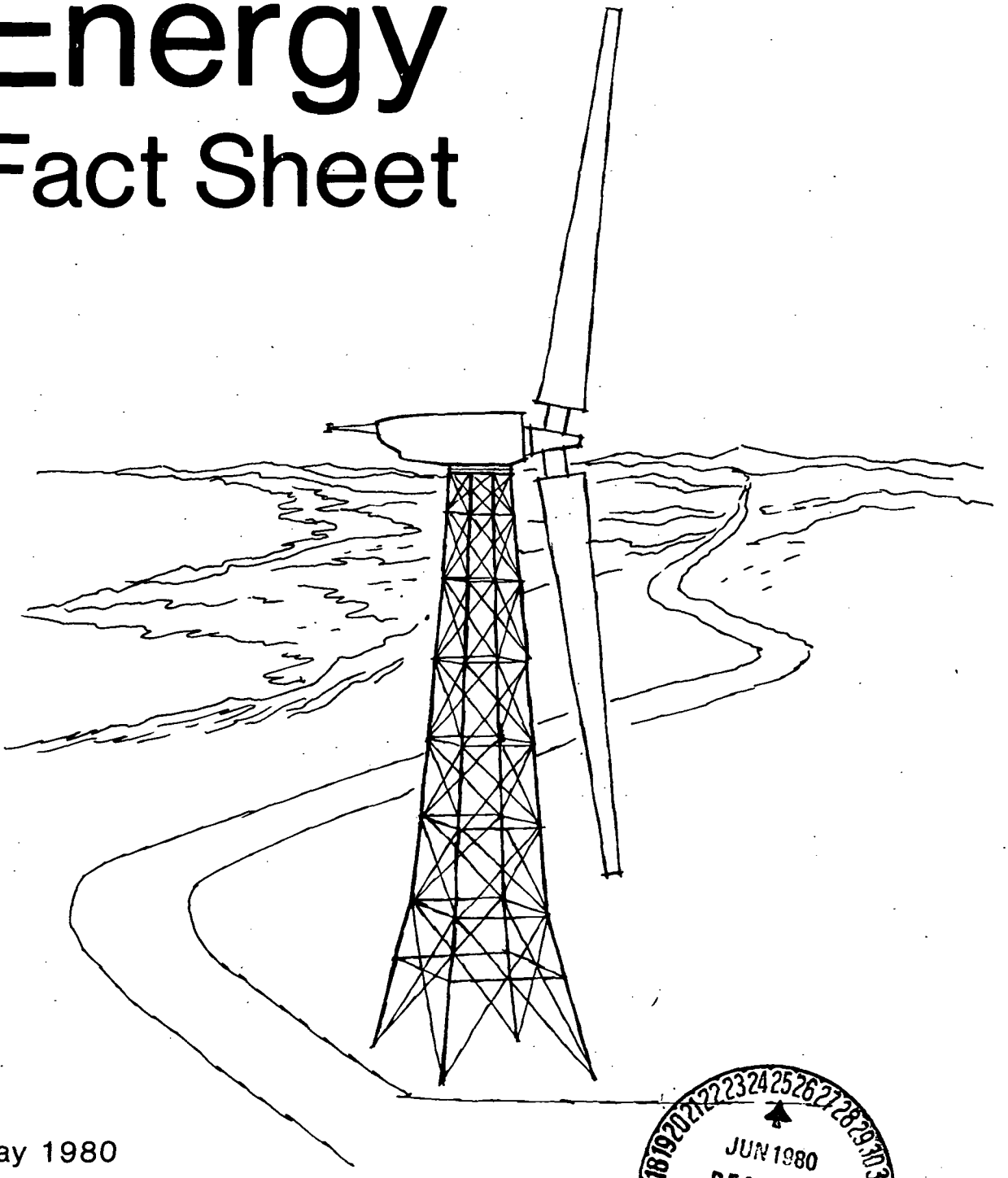
Mr. French
P80-10088

NASA
National Aeronautics and
Space Administration

Energy
Fact Sheet



May 1980
Release 80-59

RELEASE NO: 80-59 May 1980

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NASA ENERGY TECHNOLOGY APPLICATIONS PROGRAM

Office of Aeronautics and Space Technology
NASA Headquarters

Introduction

The goal of the NASA Energy Technology Applications program is to use NASA aeronautical and space capabilities to support national energy research and development needs.

NASA's aerospace programs have led to a corps of highly-skilled personnel with expertise in an exceptionally broad range of scientific, technological and managerial disciplines. Their collective talents already are being employed in many fields of energy research and development.

Process

The method by which NASA skills are related to energy problems is called "Energy Technology Identification and Verification." The process leads to formation of a technology advancement plan that ultimately results in reimbursable agreements between NASA and the Department of Energy to initiate the technology advancement work.

In most of its energy-related activity, NASA's role is that of contractor and technical consultant, conducting assigned projects funded by the Department of Energy as well as other government agencies.

Program Summary

By virtue of its experience in developing aerospace technolgy, NASA brings tothe energy quest a number of special capabilitiess. Wind energy systems, for example,are essentially based on turbine and aerodynamic rotor technologies, areas in which years of aeronautical research have made NASA exceptionally qualified to pursue advancements. Similarly, NASA has long been engaged in developing technology for solar cell arrays and fuel cell powerplants to supply spacecraft power. These systems are now promising candidates for Earth applications. NASA's know-how in space system development and orbital operations could also lead to a program of vast potential: the Satellite Power Systems, which would draw multimegawatt energy directly from the Sun and beam it to Earth receivers. NASA's energy program includes development of technology for improved solar heating and cooling equipment; solar thermal electric systems which use solar heat to generate electricity; ways of increasing production in coal mining operations; processes for converting coal into clean gaseous or liquid fuels; advanced propulsion for autos, buses and other ground vehicles; more fuel-efficient industrial gas turbines; new and more effective methods of storing energy; disposal in space of wastes from nuclear reactors; and research and technolgy development to reduce fuel consumption in future civil transport aircraft.

Wind Generation of Electricity

Windmills have produced electricity in many countries for more than 50 years. The Department of Energy Wind Energy Conversion System Program is aimed at demonstrating the public utility use of reliable, cost competitive, large-scale systems with lifetimes of 20 to 30 years. The Department of Energy program also includes smaller wind energy conversion systems for irrigation water, pumping, rural electricity production and other uses.

Department of Energy has overall program management. The NASA Lewis Research Center, Cleveland, has project management responsiblity for large horizontal-axis wind turbines and associated supporting research and technology. Projects consist of progressively larger wind turbines ranging from 100 kilowatts electric energy with a rotor diameter of (125 ft.) to 2500 kilowatts with rotor diameters of 91.4m (300 ft.) or more.

In 1975, the Lewis Research Center began operating an experimental 100-k wind turbine test facility at its Plum Brook Station near Sandusky, Ohio. This wind turbine, with its 38 meter (125-ft.) diameter rotor, is providing engineering data for the design of larger machines, as well as serving as a facility for testing and evaluating improved components and subsystems.

The rotor is designed to rotate at a constant 40 rpm in wind speeds of 29 - 64 kilometers per hour (18 to 40 miles per hour). The constant rotation speed is accomplished by varying the pitch angle of the rotor blades. The rotor drives 1,800-rpm alternator which generates a standard household current.

The more recent version of the Sandusky wind turbine is the same physical size but rated at 200 kw since it is designed to operate in more windy locations. The goal of this improved version is to gain experience in operating wind turbines in conjunction with electric utility networks. Four of these turbines have been installed in Clayton, N.Mex.; Block Island, R.I.; Culebra Island, Puerto Rico, and Oahu, Hawaii.

The next phase of the program required for the design and test of even larger wind turbines which could provide electrical power at lower costs than the smaller machines.

Introduced to service last fall, an even larger turbine, the Mod-1 Boone, N.C., wind turbine generator is the newest and largest operational system, designed to produce 2 megawatts, a 10-fold increase in power output over earlier units. Computer controlled, the Boone system has a 61-m (200-ft)-diameter rotor which is automatically aligned with wind direction for maximum efficiency.

The Mod-2 wind turbine, the next larger step, will produce approximately 2.5 megawatts using a 91-m (300-ft) or larger diameter rotor. The larger rotor of the Mod-2 will permit rated power operation at lower wind speeds, increasing the number of geographical sites at which wind turbines could be located, at the same time, increasing the total annual electric power output. The Mod-2 machine is designed to operate at sites where the mean wind speed is 23 kph (14 mph). Sites with such winds are common throughout the United States. The Mod-2 machine could produce enough energy to power 1000 average sized homes.

Photovoltaic Solar Cells

Solar cells convert light (even on cloudy days) directly into electricity without moving parts. The objective of the Department of Energy Photovoltaic Conversion Program is to develop low-cost, reliable photovoltaic systems and to help create an industrial capability to produce and distribute these systems for widespread use by 1986.

Solar cells have provided electricity to operate were NASA spacecraft, and are used on Earth in remote land and sea areas to provide power for automated weatherstations and navigational buoys. So far, they have been too expensive for conventional industrial, residential or commercial uses.

Various proposals to use solar cell systems are under consideration by Congress and the Department of Energy. One concept, the Solar Power Satellite involves locating large solar cell arrays in space and transmitting their power by microwave to ground stations for distribution.

High cost is one of the important problems to be overcome before solar cell systems receive widespread use.

Responsibility for two project activities has been assigned to NASA by the Department of Energy: the Low-Cost Silicon Solar Array Project is being conducted by the Jet Propulsion Laboratory, Pasadena, Calif., and a portion of the Photovoltaic Test and Applications Project is being conducted at the Lewis Research Center.

The initial emphasis of the Jet Propulsion Laboratory project is on technology to improve the design, efficiency, reliability, and lifetimes of solar arrays. Included are efforts to produce low-cost silicon material, large area silicon sheets, and high-volume, cost effective automated array assembly techniques.

Some of the arrays produced by the Jet Propulsion Laboratory are then delivered to the Lewis Research Center System Test Facility, which has a capacity of 10 kilowatts. It is being used to develop an understanding of how these arrarys may be successful integrated into effective power systems for a variety of uses.

Lewis also has responsibility for developing applications of small photovoltaic conversion systems. Among the applications which have been installed for test and evaluation are units for two U.S. Forest Service lookouts in California, four Depart ment of Agriculture insect survey traps in Texas, refrigeration units for remote operation and a highway dust-storm warning sign in Arizona.

In one such application, jointly sponsored by the Department of Energy, NASA, the U.S. Public Health Service, and the Papago Indian tribe, the 95-person Papago village of Schuchuli, Ariz., became the world's first solar electric community in 1978. Remotely located, Schuchuli had never had electricity until Lewis installed the 3,500-watt solar cell array which provides Sun-derived power for lighting homes and community buildings, water pumping, family refrigerators, a communal washing machine and a sewing machine.

Satellite Power System

A concept of considerable potential in meeting future energy needs is the Solar Power Satellite and Earth orbiting power station which would use solar energy to produce enough electricity for the needs of a large city. A number of such satellites could generate a significant portion of the nation's power requirements in the 21st century. Each individual satellite would be a large space platform, converting sunlight into electricity which would be microwave to Earth and reconverted for consumer use. NASA and the Department of Energy both are investigating the technical, economic, and environmental considerations of the concept.

Direct Solar Heating and Cooling

The object of the Department of Energy program is to develop cost-effective, reliable, commercially-acceptable solar heating and cooling systems for use in various building types under different climatic conditions. Working with the Department of Energy, NASA's Marshall Space Flight Center, Huntsville, Ala., has been assigned responsibility for: developing systems for use in demonstration programs; the technical and management support of the Department of Energy is commercial demonstration program and design and operation of a national solar heating and cooling data collection and analysis system.

Marshall has awarded 36 contracts to industry for development of a wide range of solar heating and cooling equipment. Contracts range from supplying existing components for integration into systems, to the development of new advanced technology systems.

For example, the Kaw Valley State Bank, Topeka, Kan., is both heated and cooled by the solar panels on the roof and associated heat storage, heat exchanging and ducting equipment. It is one of more than 100 residential and commercial demonstration facilities in the program. Nasa installs sensors at each site to monitor the performance of solar equipment; the results are taped, analyzed and then evaluated.

Solar Air Conditioner

The Marshall Space Flight Center has developed a highly efficient home air conditioner powered by heat from the Sun. Solar-heated fluid is used to drive a small turbine, which in turn drives a standard compressor like those in existing air conditioners. The unit has a cooling capacity of almost three tons, sufficient to cool the average U.S. home. The system includes a specially designed auxiliary electric motor which powers the unit at night or on cloudy days when solar heat is not available. The motor doubles as an electric generator, a feature which offers an interesting bonus: when there is more solar power available than is needed for air conditioning, the motor can produce electricity which can be used elsewhere in the home. Successfully tested in a demonstration home in Duffield, Vir., the system shows promise for commercial availability at competitive prices by the mid-1980s.

Solar Thermal Electric Power Program

The NASA Jet Propulsion Laboratory is managing a Solar Thermal Electric Power Program which uses high-temperature parabolic Sun concentrators. The objective is to demonstrate that this system can be a cost-competitive alternative by the mid-1980s. Achievement of this objective will require substantial improvement in efficiency and reduction in overall costs.

Underway is a conceptual design of a one-megawatt power station. The first advanced components are being combined in a prototype system and tested at a Jet Propulsion Laboratory test site near Lancaster, Calif.

In a conceptual design, the Sun's rays would be focused by the parabolic reflector onto a heat receiver which would act as a heat source for an engine connected to an electric generator. A concentrator, 8 m in diameter (26 ft), is expected to generate approximately 15 kw of electric power. Many modules eventually could be combined to provide higher power levels.

An important feature of the design concept is the use of foamed glass as a support structure for a high-efficiency solar mirror concentrator. Foamed glass is relatively low in cost, light, strong, rigid, weather-resistant and compatible with glass mirror surfaces. NASA believes it may have high potential for this application.

Advanced Ground Propulsion

The Department of Energy Heat Engine Highway Vehicle System Program is focused on the development of new engines which might replace the conventional spark-ignition or diesel engine used in present day automobiles. The Department of Energy Electric and Hybrid Vehicle Systems Program is aimed at advancing the state-of-the-art in electric and hybrid vehicles to permit them to compete with existing transportation systems.

Heat engines refer to engines which use fuel like gasoline, coal or kerosene.

Work on advanced heat engines, being managed at the NASA Lewis Research Center, is directed at two continuous-combustion engine concepts: gas turbine and Stirling-cycle engines. Both engines offer the potential of multi-fuel capability, low emissions and improved fuel economy. Multi-fuel capability will become of increasing importance in the future as synthetic fuels become available.

The principal interest in electric vehicles stems from the fact that their sources of energy—electricity—would be provided by electric utilities which may use coal or nuclear energy rather than petroleum. Other advantages of the electric vehicle are re low noise and little use of energy while stopped in traffic.

The present capabilities of electric vehicles, however, have limited their general application. Current vehicles have only limited range and comparatively poor acceleration and high speed performance.

In September 1976, Congress passed the Electric and Hybrid Vehicle Research, Development and Demonstration Act. The act, which the Department of nergy is responsible for implementing, is intended to accelerate the use of these vehicles in our transportation system.

One requirement of the act was for a thorough assessment of current electric vehicles, to provide focus and direction for future efforts. This assessment has been conducted for the Department of Energy by the NASA Lewis Research Center with support from the NASA Jet Propulsion Laboratory and others. Propulsion system research and technology efforts are underway at Lewis. Industry-conducted vehicle technology demonstrations are underway under Jet Propulsion Laboratory management.

A key component of an electric vehicle, of course, is its energy storage battery. One new type of battery, the nickel-zinc battery, which uses some key technology originally developed for space applications, is being tested in vehicles at Lewis. Results, to date, show that the driving range is about double compared with a conventional lead-acid battery. However, much more development work is required to make the nickel-zinc battery cost competitive with lead-acid types.

Four Greyhound buses have been equipped with advanced gas turbine engines, instead of the customary diesel engine, and are operating on Washington-Boston routes in a two-year experiment to determine what fuel and maintenance savings may be realized by substitution of turbine engines. A major advantage of turbines is their ability to operate efficiently on virtually any type of flammable liquid. A key part of the experiment involves running the buses on methanol and ethanol, two forms of alcohol.

Energy Storage

Energy storage is an essential element to many energy conversion systems. Some of these systems already have been mentioned (solar heating and cooling, photovoltaics and wind). These systems must store energy when the Sun is not shining or the wind is not blowing.

Several high-temperature thermal storage concepts are under investigation. One calls for the use of pressurized hot water, others include the storage of heat in molten salts and in steel ingots.

NASA is also investigating mechnical and battery techniques for energy storage.

Mechanical storage involves the use of high speed flywheels. Although the basic technique is not new, NASA is attempting to improve them by reducing friction.

Sponsored by the Department of Energy, NASA's principal effort in the area of batteries centers on development of a storage battery which uses inexpensive materials, operates at room temperature and can be made large enough for use in electric utility operations.

Lewis Research Center has developed as novel battery called Redox which possibly could be they think can be produced for one-third the cost of conventional lead batteries.

In Redox, as in conventional batteries, electrical energy is changed to chemical energy for storage and reconverted to electricity when needed. The difference is in the method of conversion. Redox employs a "stack" of flow cells through which two reactant fluids are pumped. Within each flow cell, the fluids are kept separate by a special membrane.

The fluids transfer electrical charge through the membrane as each fluid reacts with separate electrode surface and the electric energy thus produced is withdrawn from the system. For recharging the battery the fluid are simply pumped through the stack again, but with electrical energy supplied by an outside source.

In addition to reduced cost, Redox advantages include long useful life, estimated at 20 to 30 years; ease in monitoring and correcting changes in output voltage and total storage capacity without interrupting system operation and flexibility in sizing the stack and storage tanks for desired power output and recharge time.

Stationary (On-Site) Power

The electricity needed by industry is supplied largely by electric utilities. But industry also burns light oil or natural gas to suuply processing heat, usually in the form of steam. It is possible to meet all industrial energy needs with a single system located at the industrial site and up to 80 percent of the available energy in the fuel can be used. This approach, called cogeneration, can save significant quantities of fuel.

The gas turbine is one of several power systems which can be used in cogeneration systems. The Department of Energy assigned the NASA Lewis Research Center the responsibility for advancing the technology of gas turbines needed to make them effective power devices for such use.

In this program, Lewis is developing and testing new combustor designs which will permit the burning of heavy oils, while reducing the emissions, to broaden the range of usable petroleum fuels in the near future. Long term research is also underway to investigate how these new combustors might be adapted to burning synthetic liquid fuels when these fuels become available. Lewis is also studying cogeneration technology alternatives, to identify other power systems which also might be used in industrial cogeneration systems.

Lewis is also investigating for the Electric Power Research Institute new kind of gas turbine blade coating, called the thermal barrier coating, to improve gas turbines for utility service. The coating may permit higher turbine operating temperatures which would improve efficiency and allow the burning of heavy oils in the turbine. This activity is closely related to the cogeneration gas turbine work for the Department of Energy.

Another power system with the potential for conserving energy is the fuel cell. The fuel cell supplies electricity very efficiently and provides hot water as a product of the fuel-to-electricity conversion process. Fuel cells take two forms of chemical energy and convert them directly into electrical energy. Because the fuel cell is quiet and very clean, it could be used in large residential and commercial complexes, where the hot water would be used for space heating.

Magnetohydrodynamics is a power generation method in which fuel is used directly to produce electricity. By passing very high temperature gas through a channel surrounded by a strong magnetic field, electrons in the gas flow to collectors producing electricity. The attractiveness of this system is the promise of high efficiency and the use of burning coal as the fuel for electric utility services.

Lewis is supporting the Department of Energy's development of magnetohydrodynamics by providing studies of systems and engineering analysis of critical system components. The results of this work will address issues of cost and performance and will be used to guide future development activities.

In 1977, the Jet Propulsion Laboratory began to explore the idea of applying an extruder concept to provide a continuous flow of coal into high-pressure coal conversion reactors. High-pressure coal feeding for the next generation high-Btu gasifiers has proven to be a difficult problem to solve. It appears that extruding heated coal, just as plastics are extruded during fabrication, might provide a solution. Jet Propulsion Laboratory carried out tests on a small device and verified that coal could be extruded. Based on these results, the Department of Energy is continuing research.

NASA is looking at another possible use of the coal extruder concept, enhancing coal gasification reactions. Because the coal exiting from the extruder is in the form of a spray, it is possible to achieve intimate mixing of oxygen and steam with the coal, thus improving coal conversion reaction rates. High reaction rates have been measured, but investigations need to continue to determine how much of the coal is actually converted to fuel gas.

Advanced Coal Extraction

The Marshall Space Flight Center is investigating a production process involving the cutting and transportation of coal in an underground mine. The basic tasks of this program are the conversion to automatic control of some functions which are currently performed manually in hazardous locations. The basic functions being studied are the automatic measurement of the depth of coal left by the cutting drum and the use of these measurements in the control of the cutting drum; the maintenance of a straight cut on the face of the seam and the control of the shearing machine's roll angle. The most successful approaches to the measurement of the amount of coal left include: the nucleonic sensor utilizing a source of gamma rays; the natural radiation sensor which measures the number of gamma rays emanating from the shale and radar which measures the thickness of coal.

Aeronautics

Fuel costs account for some 20 percent of the total operating expenses of airlines. As fuel prices climb, aircraft fuel economy becomes more important.

NASA has identified technologies that can cut fuel consumption of future civil air transports in half.

Based on estimates of the size of the domestic commercial air fleet in 2005, the NASA-identified technologies would save about one million barrels of fuel daily.

Magnetic Heat Pump

A new method of producing heating and cooling has been developed by the Lewis Research Center. Ordinarly heat pumps typically give 40 percent as much heating or cooling as an ideal, perfectly efficient machine could. The special characteristics of the magnetic heat pump might achieve as much as 60 percent efficiency.

Heat pumps commonly used today for heating, cooling and freezing operate on the principle that fluids evaporate at varying temperatures and pressures. They generally employ freon or ammonia as the refrigerants.

The magnetic heat pump, on the other hand, uses a magnetic solid as the refrigerant. Its operation is based on the natural phenomenon that many magnetic materials become warmer when they are subjected to a magnetic field and cooler when that field is removed.

Electricity Saver for Home and Industry

A Marshall Space Flight Center invention, called a Power Factor Controller, has the ability to reduce by as much as 50 percent the amount of electricity used in domestic and industrial electric motors.

The alternate current induction motors commonly used in homes and industry require almost the same amount of electricity when idling (unloaded) as when they are fully loaded. When idling, a large percentage of the power they consume is cast off as heat.

The Power Factor Controller, when attached to a motor, determines the precise amount of electricity needed by the motor to perform its work efficiently.

When it senses a light load, it cuts back the voltage level to the minimum required. This reduced voltage causes current flow to drop as well, reducing the power normally wasted through heat loss.

Sixty-four percent of all electricity generated in the United States goes to operate electric motor, thus this device's potential for achieving energy savings is enormous.

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